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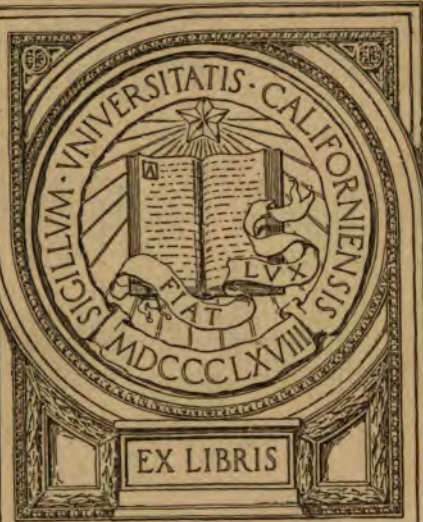
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SPECIAL REPORT

S. M. Hilgard

CHIEF OF THE WEATHER BUREAU

TO THE

SECRETARY OF AGRICULTURE.

1891.

Published by authority of the Secretary of Agriculture.

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SPECIAL REPORT
OF
CHIEF OF THE WEATHER BUREAU.

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D. C., October 1, 1891.

Honorable J. M. RUSK,
Secretary of Agriculture.

SIR: In compliance with your request I have the honor to submit, herewith, the following report, being a general summary of the operations of the Weather Bureau since its transfer to the Department of Agriculture on July 1, 1891.

Very respectfully,

MARK W. HARRINGTON,
Chief of Weather Bureau.

The meteorological service was duly transferred to the Department of Agriculture, in compliance with the Act of Congress approved October 1, 1890, which provided that the duties of the Signal Corps pertaining to the weather service be performed, on and after July 1, 1891, under the direction of the Secretary of Agriculture; and on the date of transfer I was appointed Chief of the Weather Bureau. The Service has been reorganized with a view of carrying out the expressed intention of Congress to especially develop and extend its work in the interest of agriculture. With this provision of the law in mind estimates were submitted to the last Congress for the support of the Weather Bureau for the current year. These were favorably considered, thus making available funds which have already enabled the Service to largely increase the distribution of the forecasts and storm warnings in the agricultural districts of the country.

The working force of the Bureau, including the civilians and three commissioned officers of the Army, was transferred to the Agricultural Department on the first day of July, and the entire force was reorganized in accordance with the Act of Congress making appropriations for the support of the service during the fiscal year ending June 30, 1892. All the regular employes of the Bureau under the Signal Service administration were retained and provided for. The office force in this city was

reorganized into three principal divisions, designated, respectively, as the "Executive Division," "Records Division," and "Weather-Crop Bulletin and State Weather Service Division," while other branches of the work in the office were continued substantially under the same organization as existed prior to the transfer.

Although but three months have passed since the transfer of this important branch of public service to the Department of Agriculture, numerous improvements have been made which have been highly commended by those interested in the work, and which it is believed will result in greater benefit to the country at large. To meet the popular demand for more detailed forecasts of weather and storms in various localities in the several sections of the country, the observing force outside of Washington was reorganized immediately after the transfer by the appointment of "Local Forecast Officials" provided for in the appropriation bill; the appointee, in every case, being selected from the most experienced and competent observers of the service. These officials were assigned to duty at the larger cities of the country, with authority to make predictions for their stations and vicinity, giving the weather more in detail than the Washington forecasts, which they would thus supplement and amplify. They were instructed to make a careful study of the climatology of their respective sections, both for their own use as an aid in predicting and for publication for the information of the public; and were directed to give particular attention to the effect of the weather on the principal crops at their various stages of growth, so that they could include in their forecasts reference to this all-important subject. The extent of territory for these local forecast officials, which was at first confined to their stations and immediate vicinity, has been extended in many cases, where the incumbents were considered competent, to cover the whole state, or parts of states nearest the station; and the restriction of the forecasts to 24 hours was removed to the extent of allowing them, especially in the harvest season, to predict the weather for more than one day in advance, when the meteorological conditions were so pronounced as to make forecasts for so long a period in advance reasonably certain of verification. It is confidently expected that these officials, by close study of the climatology and topography of their sections, and of the crops, will thus be able to accomplish most effective work by their forecasts. While sufficient time has not yet elapsed to show the full result of these changes, there is ample evidence to show that they are appreciated as efforts in the proper direction to meet the wants of the public. The greater frequency of articles in newspapers published at the several stations containing data and other interesting meteorological matter also shows an awakened interest. This is doubtless the result of information conveyed to the observers that a perfunctory performance of office duties would not be satisfactory, but

that they would be expected to study and endeavor to meet the various wants, with reference to meteorological information, of the several classes of the communities in which they are located, and thus develop a live interest in the service. They were also especially directed to seek and adopt every means of speedily reaching the agricultural classes with the forecasts.

WEATHER MAPS.

The weather maps issued at nearly all the principal stations were found to be frequently so poorly prepared as to be scarcely legible, and therefore discreditable to the service. Particular attention was given to improvement in this matter, and the stations issuing maps were informed that nothing but the most satisfactory results in this respect would be accepted. In place of the custom before existing of only sending a copy of the map issued on Saturday they were required to send to this office the poorest copy of every issue of the maps. By this course this office had the means of at once knowing when a poor map issue was made, so that action to correct it might be taken. At many stations complaint was made that on account of poor material furnished them the observers were unable to do better work. For this reason a better quality of supplies was immediately secured; at the same time the observers were required to give that close personal attention to the matter without which good work cannot be done with the best material. • The result has been that the appearance, legibility, etc., of the maps have been greatly improved, and there is now rarely any complaint on that account. The issue of maps has also been authorized at Albany and Oswego, New York; Charlotte, North Carolina; Charleston, South Carolina; Marquette, Michigan; and Parkersburg, West Virginia; stations not heretofore issuing them. The edition of the maps at all the stations has been very largely increased, as they are distributed with the greatest liberality, without charge, to all persons who will display them for the information of the public. The maps are prepared at the stations with the greatest possible speed upon the receipt of the telegraphic reports, so as to catch all the mail trains, upon which they are dispatched to postmasters and others for display in cities and towns that can be reached in time for the information to be of benefit.

The weather maps—which until a comparatively recent date have only been issued at Washington—are now issued at over 60 of the more important stations, and are considered a most important feature of the service, as their usefulness is being appreciated by an ever-widening circle. They not only contain the forecasts prepared in Washington and the local forecasts, but also the data on which the forecasts are based, so that they may be studied and personal conclu-

sions drawn by every one engaged in any profession or business affected by the weather; and this includes nearly all classes of business.

As we are now endeavoring to place these maps where they can be used by farmers, the following explanations may not be out of place: The data embodied in the maps issued by the Weather Bureau are the air pressure, the temperature at 8 o'clock (a. m. or p. m.), 75th meridian time, the maximum and minimum temperatures, wind direction and velocity, the character of the weather at the hour of observation on which the map is based, either 8 a. m. or 8 p. m., and the amount of rain or snow. The charting of these data occupies about half an hour for one man, and as soon as this is completed the isobars (lines connecting places or embracing sections of equal air pressure) are drawn for each tenth of an inch; isotherms (dotted lines connecting places having the same degree of temperature) are drawn for each ten degrees; the section or sections of country having the highest and lowest air pressure are marked, respectively, "High" and "Low." The former is anti-cyclonic and the latter cyclonic in its effects, or in other words, the area covered by a high pressure of air usually has clear and cool, or cold, weather, whereas the reverse is the case in advance of and surrounding an area of low pressure, where rain or snow and cloudiness, with a comparatively high temperature prevail. The drift of the atmosphere being from west to east, the charting of these cyclonic and anti-cyclonic areas, by isobars, is necessary to show at a glance their respective centres and the directions in which they are heading, graphically portrayed by the curvature of the several unbroken lines, and by the arrow showing the wind direction, the air flowing into the "Low" with a spiral inward motion, contrary to the movements of the hands of a watch, and out of a "High" with the hands of a watch. After a little study on the part of the intelligent observer, it is evident that the nearer the areas of high and low pressure are to each other, and the greater the difference in the pressure, the more rapid will be the flow of air from the greater to the lesser pressure. The isotherms (temperature lines) vary according to the isobars. If a low pressure area is advancing eastward over the middle latitudes and a high pressure area is moving eastward from the far west or northwest, the isotherms will assume toward the perpendicular; if the conditions are static, *i. e.*, that there is but little variation in the pressure, the isotherms will appear in a nearly horizontal position, according to the latitude. Cold waves, weather and temperature changes, the probability of thunderstorms or other severe local storms are easily located by giving the daily weather maps a moment's study. The several laws of storms will gradually unveil themselves to the mind of the student of the map, and the apparently unintelligible mass of lines and figures of a day becomes the guide for business transactions of any character. That severe local storms occur in the southeast quadrant of a low pressure area; that the winds will back from southwest to northwest if a low

area pressure moves south of a given place, or shifts from northeast to southwest as the storm moves north of the place; that the temperature rises in advance of a storm, and falls after it has passed; that storms generally move in the direction of the greatest rainfall, or snowfall, or where the air is most humid, are all facts evolved by a study of the maps. It is desirable that all maps issued should contain an explanation of the meteorological features affecting the district for which the map is published, and several of the more efficient local forecast officials give, in addition to the local forecasts and data on the sheets, interesting synopses of the general meteorological conditions and the probable movement of storm centers and accompanying disturbances, with pertinent reference to crop interests. It is only when some change is made in the weather map that it is learned how many and various are the classes of people who find it profitable to make a study of them.

There is no doubt that the increasing issue of these maps is educating a constantly increasing number of persons as to their proper use. It is commencing to be realized that by study of the information contained on the maps in connection with local weather signs, practical deductions as to coming weather changes may be made with profit by all who give the slight attention necessary to an intelligent understanding of the general principles governing the movement of storms over the United States.

STATIONS DISCONTINUED, ESTABLISHED, ETC.

A number of stations, nearly all of which were at military posts, have been entirely discontinued since July 1, as their maintenance at such points was not considered necessary to this service. In other cases stations at military posts were discontinued and in their places new ones established at the nearest city or town; as it is considered desirable, whenever practicable, to have the stations at business centres where, in addition to securing the meteorological data necessary for making the general forecasts, the material interests of the community can be served, by the forecasts, reports, etc., of this Bureau, rather than at military posts where, as a rule, the stations are only valuable in furnishing data. There are still a few stations at military posts the transfer of which to business communities is now being considered and arranged. The transfer of the station at Fort Grant, Ariz., to the Agricultural College and station at Tucson, has been made and the transfer of another to an agricultural station is under consideration.

STORM SIGNALS ON THE SEABOARD AND GREAT LAKES.

As to the special display stations where storm (wind) signals are shown for the benefit of maritime interests, the limited appropriations have not permitted the establishment of any additional stations of

this character at which the displayman is paid, but there have been several such stations established upon the urgent request of interested parties who agreed to have the signals displayed without cost to the Government. This evidence of the appreciation in which these storm-signal displays are held is further corroborated by the very recent communication from the harbor-master at Bridgeport, Conn., who stated, in offering to have the flags displayed without compensation from the United States, that forty years experience as a mariner on Long Island Sound had proved to him the value of these signals.

It is hoped that the appropriations for next year will permit the establishment of display stations, and the payment of the very small compensation to the displayman, at all points at which the benefit to shipping interests will justify it.

It is in contemplation to give special attention at an early date to the meteorology of the Great Lakes, as related to maritime interests, and an experienced observer has just been appointed to take charge of this important matter.

COTTON REGION SERVICE.

The daily cotton region reports, consisting of maximum and minimum temperatures and rainfall, taken by special observers throughout the cotton belt of the South and telegraphed to the regular observers of the Weather Bureau, as centers, where they are tabulated and means telegraphed to the other cotton region centers and to the cotton exchanges in large cities, meet with great favor; and this year especially, on account of the poor condition of the cotton crop, they are eagerly scrutinized by all concerned. Arrangements have recently been made by which these reports from special cotton region stations, which heretofore were sent only to the Weather Bureau centers, are now transmitted also to the several state weather service headquarters, where the information they contain is used for incorporation in their monthly publications, weather-crop bulletins, etc., by the directors of those services. At the urgent request of those interested in cotton and at some expense, which will, however, be justified by the results, telegraphic information of the first killing frost at every cotton-region station will hereafter be included in these reports.

SUGAR REGION SERVICE.

A service similar to that now carried on for the benefit of the cotton interests has been requested for the sugar and rice interests of south Louisiana. It is designed to establish not exceeding ten stations of observation in the sugar region from which reports of temperature, rainfall, and frost will be telegraphed to a designated center daily, and this information will be given the press for publication and disseminated generally throughout the sugar belt in bulletin form, for the information of the planters and factories.

WEATHER BUREAU EXHIBITS.

At the New York and New England Fair, held at Albany, N. Y., August 25–September 1, an exhibit was made by this service, showing the working of a Weather Bureau station, including the instruments used, the issue of the weather map, etc. Maps, bulletins, and other publications were distributed with the greatest liberality, and thus the service was brought to the attention of a very large number of people who heretofore had only vague ideas of its operations. The exhibit met with great favor and the numerous newspaper comments were very flattering. It is the intention to make these displays at other such exhibitions so as to give the people who attend them a more intimate acquaintance with the workings and objects of the Bureau, with a view to their participating in its benefits.

WEATHER FORECASTS.

Realizing that the work performed in this branch of the service is of the first importance, attention has been especially directed not only for the improvement of the weather forecasts but their wider distribution, particularly in the agricultural districts.

A general statement of the weather conditions and the general forecasts are made at each report, and more attention has been given to the issue of the forecasts for a longer period in advance, which accompany the general synopsis of the weather conditions, and which, when practicable, are added to the predictions for the several states.

The language of the forecasts has also been revised and the use of doubtful or uncertain expressions which are not clearly understood by the public is avoided.

The following is a general synopsis of the manner of preparing and distributing the official weather forecasts of this office:

A set of five charts is prepared twice a day from the 8 a. m. and 8 p. m. observations, showing (1), general weather conditions; (2) pressure changes and departures from the normal; (3) temperature changes and departures from the normal; (4) cloud conditions, maximum and minimum temperatures and changes, and local weather forecasts, and (5) dew-points and changes. Reports from about 160 stations in the United States and Canada are entered on these charts.

Tracings of the isobars and isotherms and areas of marked precipitation as shown on Chart 1 are furnished to the lithographer.

A general statement of the weather conditions that have prevailed during the past 24 hours and a general forecast of the weather for the succeeding 24 to 48 hours is then made, and followed by a detailed forecast for 42 separate states and districts.

Reports from 26 river stations are entered on the form once a day at the a. m. report and forecasts of river changes made. The complete forecasts are set in type.

At each report tables are set in type showing pressure and 12-hour changes, temperature and 24-hour changes, maximum or minimum temperatures, wind velocities, and precipitation at each station, and a symbol map is prepared showing direction of the wind and state of weather at each station. Copies of the forecasts, table, and symbol map are furnished to the lithographer and additional copies of the forecasts distributed to the city newspapers and to the telegraph companies and press associations. The forecasts are also distributed by means of special telegraphic messages to observers and others at central points throughout the country to be by them distributed to other points in their respective localities, about 90 of these messages being sent daily.

Storm warnings to the lake, seacoast, and Canadian stations, warnings of frosts to the sugar, fruit, cranberry, and tobacco districts, and warnings of cold waves and dangerous floods to the threatened districts, are sent whenever the conditions indicate them.

Special telegrams to individuals, giving forecasts for certain specified localities and dates, are sent whenever requested, at the applicant's expense.

A daily cablegram is prepared at the p. m. report and sent to the French Meteorological Bureau, Paris, giving observations and marine data obtained from reports of incoming vessels and certain other data taken from the p. m. charts.

The verification of the p. m. forecasts and the justifications of storm and cold-wave warnings are determined and percentages computed.

WEATHER-CROP BULLETIN AND STATE WEATHER SERVICE DIVISION.

The Weather-Crop Bulletin issued by this Bureau weekly has been greatly appreciated during the current season by those interested in agriculture, as it presents truthful statements of the condition of the staple crops at short intervals, and these statements having been distributed throughout the country have enabled the producer to become familiar with the exact crop prospects and, therefore, to form a correct estimate of the probable value of the product in which he is interested.

The work pertaining to this branch of the service is performed in a division known as the Weather-Crop Bulletin and State Weather Service Division, which has charge of the preparation of the weekly and monthly crop bulletins and a supervision of the work of co-operating state services, reports from which form the basis of the crop bulletins. This division also has charge of the establishment of stations for the display of weather signals and the distribution of frost warnings. Immediately upon the organization of this division correspondence was entered into with the weather observers in several states where state weather services were not organized, and this correspondence has

resulted in the establishment of new state and territorial services, so that at present almost every state and territory in the Union is provided with a local co-operative weather service which forms a channel through which the benefits of the work of the National Service may be conveyed more extensively and more promptly to the people.

Since the 1st of July new weather services have been organized in Arizona, California, Florida, New Mexico, North Dakota, Oklahoma, Utah, Virginia, Washington, West Virginia, and Wyoming, making the number of state services in operation on September 30, 1891, thirty-nine, and to meet the demands of the cotton growers of Georgia it is proposed to organize at an early date a complete local service in that state.

While the organization of new state services has been in progress much attention has been devoted to a general supervision of the work of those co-operating services previously established, the desire being to greatly increase the number of voluntary meteorological observers and crop correspondents, and to effect a more thorough dissemination of current weather-crop information among those classes of people most likely to be benefited thereby. More than a hundred new voluntary meteorological stations have been established and equipped with instruments at the expense of this Bureau since July 1, and nearly as many have been established by this Bureau, but were furnished with instruments at private expense.

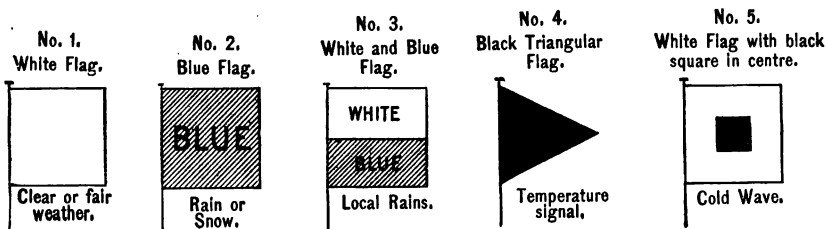
The reports from voluntary observers serve a twofold purpose: For agricultural societies and experiment stations, giving them accurate meteorological data on which to rely in dealing with experiments on vegetation, etc.; and the reports of rainfall, temperature, sunshine, etc., are utilized weekly in the weather-crop bulletins as standard meteorological features for the state or territory, while the compiled monthly conditions are utilized in various ways in establishing the climatology of the state, and as a record for physicians in the study of the relation between climate and disease.

The most practical and most highly complimented portion of the exclusive work of the state services is the issue of the weekly weather-crop bulletins. These are sources of reliable information for all interested in agriculture, following up the season from week to week so that an excellent estimate can be made at any time relative to the crops of any county, state, or the country at large. These bulletins have a thorough dissemination in all the states and territories in which state services are in operation, and are highly spoken of by the press and public. The National Bulletin published weekly by this office during the growing season deals with the weather of the week throughout the country, consisting of charts showing the departures of temperature and rainfall, the table of seasonal and weekly departures of like data, besides giving a discussion of such charts and tables, with

edited telegrams received from the several state services showing the actual condition of crops and the effect of the week's weather thereon.

DISPLAY STATIONS.

On June 30, 1891, there were about 630 weather-signal display stations in operation to which the Government telegraphed the forecasts; 90 stations to which cold-wave warnings were telegraphed; 51 frost-warning, and 6 (California) rain-warning stations. On September 30 there were over 1,200 weather-signal display stations in operation, an increase of about 100 per cent. in less than three months, and with a constant demand for additional stations from all portions of the country. Since these displays of weather signals were for the immediate benefit of the agricultural interests, and since the number of stations in operation was totally inadequate to give the information to the people of the country, steps were immediately taken to have 50 additional stations for the display of weather flags established in each of the states of the Union, and such establishment is now in progress, Wisconsin having established nearly double the number first allowed, besides having perfected a system of frost warnings for the benefit of the cranberry and tobacco growing interests. The state service directors in the tobacco growing states have all been instructed to perfect similar systems for the dissemination of frost warnings, the result in Wisconsin alone having been so thoroughly satisfactory that a warning of a killing frost for the cranberry interests on August 24 resulted in the saving of over one-third of the cranberry crop (representing over \$125,000) through flooding, whereas the remainder of the crop was totally destroyed, owing to no facilities for protecting it from the predicted frosts. In Minnesota and the Dakotas frost warnings were issued during August of the current year to protect the grain, and little or no damage resulted where farmers used smudges to cover their fields with a dense smoke during the period of anticipated frost. In the state of Kentucky alone nearly 150 frost-warning stations were established and are now in operation to protect the tobacco interests of that state.



The weather and temperature flags in use by the Weather Bureau are five in number: A white flag to indicate fair weather; a blue flag for rain or snow; a white and blue flag, colors arranged horizontally, white above and blue below, to indicate local rains; a triangular black flag

is the temperature pennant, which, if hoisted above either of the foregoing symbols, indicates higher temperature, and if below, lower temperature; and lastly, the white flag with black square in center to indicate cold waves. This latter flag is also used as a frost symbol. This system of flags has given universal satisfaction, owing to its legibility and simplicity. The local rain flag (half white and half blue) has been added since the transfer of the Bureau to the Department of Agriculture, and was necessary to indicate the frequent summer conditions when local showers were probable in agricultural sections, and when either the white or blue flags would be misleading. The purchase of these flags was formerly at the expense of the displayman, and continues so to a certain extent, the appropriation for this purpose for the current year being very limited, permitting the purchase of not to exceed 600 sets of flags, whereas there are double that number of places receiving daily forecasts, with the possibility of an increase to three or four times that number. It is therefore necessary for many cities, towns, firms, or individuals to supply the flags for display, the expense for the set, flags six feet square and of good bunting, costing from \$7.00 to \$7.50. They can be purchased from any flag maker in any of the larger cities of the country, or may be ordered through the directors of the several state weather services.

The several methods of disseminating weather forecasts and warnings at present in vogue are by means of flags, bulletins, and stationary steam whistles; and besides such forecasts as are telegraphed at Government expense, displays are made and bulletins are posted at thousands of cities and towns where this weather information is received free over private telegraph and telephone lines and by means of the daily press.

RECORDS DIVISION.

This division was reorganized on July 10, 1891, with a reduction in force of about 25 per cent. It has charge of the receipt and compilation of all meteorological data, including the necessary correspondence, and the custody of the meteorological records of this office. The work of this division was continued substantially as previously performed, which was about as follows:

CHARACTER OF WORK.

1. Receipt, care, and acknowledgment of meteorological forms and reports of whatsoever character.
2. Examination of the more important meteorological reports.
3. Preparation of statistics for the Monthly Weather Review, the annual reports of the Chief of the Bureau, the several divisions and professors of the central office, and the public.
4. The preparation of reduction tables and normals; the selection,

in conjunction with the Weather-Crop Bulletin and State Weather Service Division, of voluntary stations, and the preparation of a brief history, by card record, of each meteorological station.

The usual number of meteorological forms and reports (over 15,000 monthly) have been received and promptly distributed.

The promptness with which the statistical work of observers has been performed is especially noteworthy, in view of the increased labor naturally involved in extending the scope of the Bureau in other lines of activity. But most gratifying is the fact that the voluntary observers, upon whom the Bureau must depend for a large measure of its success in climatological work, have continued their active co-operation in an unbroken body. In 1874, when the Smithsonian Institution transferred its climatological work to the Signal Service, a very considerable percentage of voluntary observers ceased reporting, and in less than six years the original number had been reduced one-half. That the transfer of the Weather Bureau to the Department of Agriculture, however, meets with the hearty approval of this class of reporters needs no more striking demonstration than that afforded by the continued co-operation of all the old observers, as well as by the relative increase in new observers during the three months just passed.

PREPARATION OF STATISTICS.

Review tables.—Meteorological tables for use in the preparation of the Monthly Weather Review have been completed for July, and the greater number of those for August are in process of completion.

The table containing monthly results of observations at the regular stations has been recast and enlarged. The additional data now published will, it is believed, be of value in the current work of the office as well as to students of meteorology in general.

Annual report tables.—Tables of monthly and annual mean temperature at 1,954 stations; monthly and average precipitation at 2,254 stations, all for the calendar year 1890, and a table of first and last killing frost for the season 1890-1891, from 951 stations, have been completed for publication in the Annual Report of the Weather Bureau for 1891. These tables are especially valuable in the current work of the office and enable the division to supply information to the public which it would not be possible otherwise to furnish.

Climatic data.—These have been supplied to the officials of the central office and to the public in 71 cases during the three months just past, of which four cases were authenticated under the seal of the Department, for use as evidence in courts of law.

A policy of the utmost liberality, consistent with the clerical force available and the interests of the General Government, has been instituted with reference to the amount of meteorological data which shall be supplied to individual investigators. The amount heretofore furnished on a single application has been limited to what a good clerk

could prepare in two hours, and while the operation of the rule has been beneficial in many cases, yet it has doubtless deterred many worthy investigators from making free use of the abundant data in the files of the Weather Bureau.

The private investigator is always a powerful auxiliary in the development of each branch of science; meteorology, however, with its intimately allied branch, climatology, has been unfortunate in this respect, inasmuch as the great mass of observations heretofore made are practically inaccessible except to a limited number of persons in the central office of the Weather Bureau. With a view, therefore, of disseminating information as to the nature and character of meteorological observations already made, a recent compilation prepared by the Records Division, viz., "Index of Meteorological Observations in the United States," will shortly be sent to the principal stations of the Weather Bureau so that it will be possible to give greater publicity to the material contained in the records of the office than has been possible heretofore. Arrangements are also being made by which private investigators can make use of our accumulated data under such restrictions only as will assure the integrity of our records.

VOLUNTARY OBSERVERS.

The voluntary observers of the Weather Bureau, comprising public-spirited citizens and professional men in all parts of the country, continue to render valuable services in observing and recording the daily phenomena of the weather. The transfer of the Weather Bureau to the Department of Agriculture has had no appreciable effect upon this corps of observers, except to increase its numbers, the percentage of increase during July and August being greater than at any time during the year ending June 30, 1891, due to the more liberal policy pursued regarding the issue of instruments in agricultural districts and to the establishment of the eleven new state and territorial state weather services.

The gratitude of all thoughtful persons is due to these isolated observers, who, by giving a portion of their time to recording the changing conditions of the weather, furnish what must ultimately yield valuable results, both to themselves and to the country in which they live.

The mode of procedure in establishing voluntary stations, and in loaning Government instruments, has been radically altered within the past month. The essential feature of the change from old methods is in granting Weather Bureau observers in charge of state centers authority to establish new stations, or to renew the equipment of old stations whenever in their judgment the interests of the service will be subserved by such action.

The observer at the state center is on the ground, and is better able to keep in touch with the needs of the various sections of his state than

the central office at Washington. Under the new arrangement, it is possible for him to equip a new station in any part of the state, or territory, as the case may be, within two days at the farthest. A broken instrument can be replaced, thus preventing a serious interruption in the record.

The great majority of voluntary observers of the Weather Bureau are equipped with a set of self-registering maximum and minimum thermometers, from which the daily extremes of temperature are obtained; a rain-gauge for measuring the amount of rain or snow that falls, and a lattice-work shelter for the thermometers to protect those instruments from the direct or reflected rays of the sun, and from the effects of rain, snow, hail, etc.

Quite a number of voluntary observers have been supplied with the dry and wet thermometers in addition to the foregoing instruments, and a number are supplied with barometers, wind vanes, anemometers, etc.

The issue of other than thermometers and rain-gauges by the Weather Bureau is not advocated, owing to the great cost of the barometers and other instruments, except in rare cases.

The dry and wet thermometer readings are of great value to the agricultural interests at certain periods of the year in foretelling local frosts. If, in the evening, the air is dry, *i. e.*, if the wet thermometer reads considerably lower than the dry thermometer, and the latter instrument shows readings as high as 50° or more, the temperature of the dew-point would be, with a difference of from 10° to 12°, in the neighborhood of 25°, and this latter figure would show nearly the temperature of the air of the following morning, under favorable weather conditions, lack of cloudiness and absence of strong winds.

In a number of states, notably Wisconsin and Louisiana, a rule was established to have all thermometers located in shelters at an elevation of from 4½ to 5 feet above some grass plat, and where the air would circulate freely, but since no shelters are at present furnished by the Government to these observers, and since the cost of such shelters cannot be less than from ten to twelve dollars, if made after the pattern used by the Weather Bureau stations, a light, portable shelter should be furnished them free, and observations made from shelters at uniform elevations by all voluntary observers located in agricultural districts, and throughout the country, if practicable.

There are at date probably 2,200 voluntary observers in the United States reporting to this office, an increase of about 400 in the past three months, and steps are now being taken to cover every section of each state or territory in the entire United States with volunteer stations of observation, so as to leave no section without stations from 20 to 30 miles apart. To achieve this it will be necessary to have certain public-spirited towns or individuals purchase the instruments and shelter, the cost of the set of self-registering thermometers, rain-

gauge, and shelter being in the neighborhood of twenty dollars. There are but 150 sets of self-registering thermometers on hand for issue, and this office has located nearly double that number of places from which observations would be desirable.

Besides the record of temperature and rainfall made by the voluntary observer, he records dates of frost, thunderstorms, the character of the weather several times daily, at stated hours, gives the wind directions, with descriptions of various meteorological phenomena. On Friday of each week during the growing season he compiles a report showing the effect of the weather upon the crops of his section, forwarding such report to the director of the state weather service. Many of the voluntary observers publish their local records in the county papers, posting the daily records of temperature, rainfall, etc., in some prominent and conspicuous place in their city or town, and taking other occasions to give the public the benefit of their enterprise and work.

It is recommended that the appropriation for instruments for voluntary observers during the coming year embrace a full set of thermometers (dry, wet, maximum, and minimum, and in certain cases the terrestrial radiation minimum, the latter instrument to be issued to determine the difference between the temperature registered by the sheltered minimum and that actually affecting plant life), a standard rain-gauge and an instrument shelter, so as to complete all sets of instruments in the hands of voluntary observers, and to loan to those who have purchased their own instruments the standard Government instruments. Such complete records, and the more liberal policy of the Agricultural Department in dealing with these most worthy observers, would result in much good to the Department.

Thus far the present year 258 thermometers and 93 rain gauges have been issued to voluntary observers as against 157 thermometers and 52 rain gauges during the corresponding period last year.

In addition to the Monthly Weather Review and the annual report of the Weather Bureau now furnished gratuitously to co-operating observers as a slight return for their voluntary services, the Honorable Secretary of Agriculture has authorized the issue of such other publications of the Department as may be of general interest.

The stimulus to greater activity, and the ultimate increase in numbers resulting from the liberal policy of the Department, cannot, however, be measured in so short a time as has elapsed since the beginning of the present fiscal year.

WORKING INDEX OF FOREIGN METEOROLOGICAL OBSERVATIONS.

By the completion of an index of meteorological observations in the United States, noted in the last annual report of the division, reference to the meteorological data of any state or territory is quickly and easily made; not so, however, when it is desired to consult the pub-

lished data pertaining to European or other foreign countries. The Records Division is frequently called upon to compile climatic statistics having reference to the conditions under which certain fruits and plants are successfully grown abroad. In order, therefore, to meet the growing demand for information of this character with a minimum expenditure of labor, arrangements have been made looking to the completion at the earliest practicable date of a working index which will show for each of the grand political divisions of the world, except the United States, the extent and character of the meteorological observations which have been made therein.

The work, when completed, will also be valuable in that it will enable the specialist to consult more readily than heretofore the accumulated data bearing upon the relation of climate to crop production, and thus contribute in a measure to the general fund of information for the better development and promotion of agricultural interests.

In the matter of climate as affecting health, the index will also prove to be a valuable aid in the current work of the division.

A compilation of climatic data for southern European countries, including the Riviera, called for during July of the present year, has shown that portions of the United States possess climatic conditions surpassing in some respects those of the health resorts and sanatoria toward which travel has been directed for a century. Little systematic effort has been made, however, except as to several places on the eastern slope of the Rocky Mountains, to place before the American people the many advantages of a climate so diversified as their own. Conveniences as to travel, the advantages of association with a kindred people, and other equally cogent reasons might be adduced to show the importance of an examination of the absolute advantages possessed by many places within the United States.

It is to be hoped that the time is not far distant when this subject will receive the full treatment it so richly deserves; in the meantime, however, the Weather Bureau will supply to interested persons information respecting the climate of any point at which a meteorological record has been kept.

The data contained in the monthly reports received each month from all classes of observers are being arranged by elements, and classified so as to be immediately available, whether for brief reference, a full examination, or for application to various economic questions.

PACIFIC COAST DIVISION OF THE WEATHER BUREAU.

The weather service on the Pacific coast has been enlarged during the past three months by the addition of a number of stations sending telegraphic reports to the central station, and the appreciation of the value of this service by the people is indicated by the increasing demand for daily weather charts and telegraphic forecasts from various sections of that coast. These warnings have already proved of great value to the

fruit interests, especially in the raisin district, where damage to raisins in process of drying was largely averted by timely warning of the approaching rains.

Special studies are being made of the peculiarities of the climate of the Pacific coast, with a view of improving and extending the forecasts of that region. Arrangements have been made for the receipt and distribution of special telegraphic reports of rainfall throughout California during the rainy season for the benefit of the commercial and agricultural interests.

To meet the demands of the commercial interests, weather reports from Point Reyes Light, Tatoosh Island, Neah Bay, and Port Angeles are published in a number of daily shipping papers of San Francisco, an arrangement which brings the information before a large number of people with the least expense and the least delay. Special display stations for weather and storm signals have been opened at Clallam Bay, Grays Harbor, Port Gamble, and Port Ludlow.

To assure complete and accurate vessel reports for the information of the shipping interests of San Francisco, the weather station at Point Reyes Light has been more fully equipped for the display of signals of the international code.

The high appreciation of the work of the weather service by the general public on the Pacific coast is an indication of its usefulness, and it is believed that the special investigations which are now being made will not only result in increased accuracy of forecasts, but will extend their usefulness to localities and interests which have not previously been benefited through the work of this service.

The weekly weather-crop bulletins issued for California and Oregon have been the means of furnishing to the people of that coast accurate reports of crops during their growth, and have furnished to the country at large, through telegrams from the state centers to this office, information which has been given the general public in the weather-crop bulletin of this service.

RIVER AND FLOOD SERVICE.

The work in charge of the River and Flood Room of the Weather Bureau is as follows:

1. The prediction of river stages daily for various places in the country.
2. The improvement of the rules according to which river predictions are made, by means of investigations based on records of river stages and rainfall.
3. The supervision of observers, the visiting of forms received from stations, the correspondence relating to river work at 110 river stations and 50 special rainfall stations throughout the country, the opening of new stations, the answering of inquiries regarding river stages, etc.

4. The classification of type-maps of isobars and isotherms preceding great areas of rainfall.

Telegraphic reports of the stages of rivers at 26 places are received daily in the morning meteorological reports from Weather Bureau stations. Predictions of stages for points on the rivers below the places are made from these reports, based on what has occurred in previous cases at points lower down, as shown by the records of river stages. The river and flood system includes the Mississippi River and its tributaries, the Savannah, and the Potomac.

In most instances when the rivers are at a medium or low stage the predictions are very general, such as, "The rivers will rise," "The rivers will fall," or "The rivers will remain about stationary." Sometimes the rivers or the parts of rivers in which changes of stage are expected are designated in a general way, as "The upper Ohio will rise, the Missouri and the lower Mississippi will fall," etc. When the rivers are near flood stages definite predictions of expected stages are made according to definite rules that have been prepared.

Special studies have been inaugurated with a view of determining more exact rules between the discharge and the stage of the rivers at various points, and thereby to make the flood forecasts of this service more accurate. A special study of weather types is also being pursued for the purpose of determining the meteorological conditions which are likely to be followed by extensive and heavy rainfalls over the drainage basins where floods are likely to occur. It is believed that in this way some improvement can be made, not only in the general forecast of rain, but also in the forecasts of probable extent and severity of floods.

TELEGRAPH SERVICE.

The Telegraph Service of the Weather Bureau is charged with the maintenance and operation of the United States Seacoast Telegraph Lines, and the auditing and settlement of all accounts for line receipts in connection therewith; also with all matters pertaining to the telegraphing of weather reports, forecasts, wind-signal orders, cold-wave and frost warnings; the auditing of the bills of the various telegraph and telephone companies for telegraphing and telephoning messages and reports of all kinds; and the preparation of all forms necessary in connection with such reports and the seacoast telegraph lines.

Since July 1, 1891, the work of the Telegraph Department has been largely increased by the additional reports furnished to local forecast stations, and the enlarged distribution of general and local forecasts and warnings, together with the increased correspondence and auditing incident thereto.

Telegrams have in several instances been changed to new and more direct routes, thus shortening the time of transmission and delivery.

The new, heavily-armored cable connecting Tatoosh Island with

Cape Flattery, Wash., was successfully laid July 21, and the entire reconstruction of the land line to Port Angeles completed August 6. Tatoosh Island was reopened as a full meteorological and vessel reporting station, and two intermediate repair stations were established at Port Crescent and Clallam Bay. The restoration of this line is of great importance to the maritime interests of the north Pacific coast, both as regards the telegraphing of vessel reports from Tatoosh Island and the value of the meteorological reports furnished from that station.

An independent wire has been provided from the Weather Bureau office at San Francisco to the cable at Fort Point, thus obviating the necessity of using a portion of the military line in communicating with Point Reyes.

The cable across the mouth of Chesapeake Bay from Cape Henry to Cape Charles, which was broken by an anchor in April last, was repaired during the latter part of July under the personal supervision of the Superintendent of Telegraph Lines, a matter of considerable local interest.

Extensive general repairs have been arranged for the Hatteras section, which will include the stringing of 70 miles of new wire and the erection of 820 new wooden poles. When this work is completed this important section will be in a very efficient state of repair.

On the Nantucket section 100 new wooden poles have been contracted for to supply an existing deficiency on Naushon Island.

INSTRUMENT ROOM.

1. The Instrument Room is charged with the issue of instruments and accessories, except rain gauges, to all the regular and voluntary observers of the Weather Bureau, and has supervision and control of the exposure of instruments at regular Weather Bureau stations; the location and erection of instrument shelters, supports, etc., and all modifications made incident to changes or removals of offices. Under this item is included the packing and other similar preparation for shipment of the delicate thermometers, barometers, and all other instruments issued; also the keeping of a complete and accurate record of the issue and location of each instrument passing through the room.

The forms and automatic record sheets from stations using self-recording instruments are critically examined and inspected by skilled assistants in this room, with a view to detecting errors in records and imperfections in the performance of the various instruments.

2. The purchase, through the Accounts Division, of all instruments and supplies and accessories thereto.

3. All correspondence incident to the performance of the above duties is conducted within the room.

4. The testing and inspection of all supplies, including extended tests of special self-registering instruments; the reconstruction of barometers and refilling of tubes; the comparison of thermometers and

barometers with office standards, and the determination and tabulation of all corrections for instrumental errors.

5. The Instrument Room has supervision of the machine shop for the necessary alteration and repair of various meteorological instruments, instrument supports, etc.

6. This room has charge of all the standard instruments of the Weather Bureau, and maintains in continuous operation a large number of special self-recording meteorological instruments arranged for exhibit.

7. The Instrument Room is constantly engaged upon special experimental studies respecting both the development of new instruments for special purpose or the alteration and improvement of those now in use, and also the study and original experimental research in connection with meteorological questions of special importance.

In anticipation of the extension of the service since July 1, and the increase in the number of voluntary stations for climatic study, early action has been taken to provide a proper supply of instruments and accessories. In a few special cases of importance the Instrument Room has furnished complete equipments of instruments, such as are used at regular second order stations. The limited supply of these sets, together with their cost and the insufficiency of appropriations, makes it possible to supply only a very few observers outside of the regular stations.

The short time since the 1st of July has been largely occupied with routine work, and particularly the duties incident to the purchase of annual supplies, etc. Various improvements, however, have been made in respect to some of the instruments, particularly the self-recording rain-gauges, rain-gauge supports, nephoscopes, and experiments are now in progress looking to the construction of a new form and greatly improved sunshine recorder.

MONTHLY WEATHER REVIEW.

The Monthly Weather Review is based upon monthly meteorological reports received from an average of nearly 2,000 regular and voluntary observers of the Weather Bureau, miscellaneous reports, correspondence, the daily press, and from other reliable sources. An average of over 300 marine reports is received monthly through the co-operation of the Hydrographic Office, Navy Department, and the data contained therein are plotted on charts of the North Atlantic Ocean, and are summarized under the heading "North Atlantic storms" in the Review. This publication summarizes the meteorological conditions and the more prominent characteristics of the weather over the United States and Canada for each month, and is mailed to co-operating observers throughout the world. It is at present edited by a board which has been directed to make successive improvements in every direction in which it may be found advisable in the interests of the service. Be-

ginning. with the time of transfer of the Bureau, the briefer studies of the scientific force are printed in the Review.

LIBRARY.

In addition to the ordinary work connected with the conduct of a library, the librarian is charged with continuing the preparation of the general bibliography of meteorology, the compilation of which was begun in 1884.

The total number of titles now on hand, in the shape of a card catalogue, is about 60,000; these titles are arranged in over 200 classes and have complete author index, so that the catalogue is convenient for ready reference.

It is expected that the catalogue may be very materially enlarged during the present fiscal year and that an appropriation may be made available for its publication so as to greatly increase its usefulness.

INTERNATIONAL CONFERENCE OF METEOROLOGISTS.

In accordance with your instructions I left the United States on August 13, accompanied by Professor Abbe, in order to attend the Conference about to be held at Munich of representatives of Weather Bureaus of different countries of the world; in this connection, also, a hurried visit was paid to the central bureaus at Hamburg, Munich, Vienna, Berlin, Paris, and London. Over a portion of our route we were accompanied by Mr. A. Lawrence Rotch, the director of the Blue Hill Observatory, and also by Brigadier-Général A. W. Greely, Chief Signal Officer. The presence at the Conference of four delegates from the United States was the occasion of many congratulatory expressions as showing that the United States had no disposition to hold aloof from these important meetings, and our intercourse during the week spent at Munich, as well as during the subsequent visits to the respective bureaus, has, we believe, served to arouse a lively interest in, and a more intelligent appreciation of, the work that is being undertaken in Washington. In some respects the numerous resolutions adopted by the Conference urging uniformity in meteorological methods were modified so as to recognize the fact that the methods in use in this country would be acceptable to European meteorologists even though they differed from those considered proper in Europe. A permanent international meteorological committee was appointed to superintend the execution of the resolutions adopted by the Congress and to provide for the convening of another similar Congress at some distant date, and the fact that the Chief of the Weather Bureau was made not only Vice-President of the Conference, but also a member of this permanent International Committee, will demonstrate to you the appreciation in which our service is held by foreign meteorologists.

Among the resolutions adopted by the Conference I note especially,

first, one to the effect that the subject of terrestrial magnetism is commended to the attention of national weather bureaus when not otherwise specifically provided for in each country; second, that the exposure of rain-gauges on the roofs of large buildings is not objectionable if they are located near the center of the roof. With regard to the heights of clouds and their more minute study a special committee was appointed which has, as I am informed, already secured about thirty stations at which the frequent determination of cloud heights and velocities will be made; the same committee will also superintend the publication of a new cloud-atlas exemplifying a new system of nomenclature. A special committee was appointed to prepare a detailed report on the relations of meteorology to agriculture. This latter subject occupied much of our time and thoughts during our rapid run over Europe, and in fact it has been deeply impressed upon every one's attention by reason of the short crops in Europe and the abundant crops of the United States during the present season. We found the north of Europe still suffering from cloudy, cold, and wet weather up to the 1st of September, and although during the first half of September we enjoyed dry, clear weather in southern Germany, Austria, France, and England, yet the crops were backward and deficient. Some of the European weather bureaus, notably those of Saxony, Bavaria, Austro-Hungary, and France, are seeking methods by which to make themselves useful to the agricultural interests. Each of these has a number of correspondents who pay an annual sum for the privilege of receiving daily predictions of the coming weather; at present these predictions are of a general character, but in Saxony and Bavaria the study of local thunderstorms and hail has progressed sufficiently to warrant them in predicting the general path of the thunderstorm with its growth and decay, when its existence has been once established at any time during the day. Doubtless a similar result can be attained in the United States or in any portion thereof whenever a network of thunderstorm observers, at an average distance of five miles, can be secured, and the efforts made in this direction in former years by the co-operation of General Hazen and the Post-Office Department deserve to be renewed.

Another aspect of the question as to the relations of the weather bureaus to agriculture is suggested by the work undertaken at forestry and agricultural stations in Europe. The short time at our disposal allowed us to visit only one agricultural station, namely, the establishment of Sir John Lawes, Baronet, Rothamsted, Herpendon, Herts, where, under the special supervision of Dr. Miller, there is still being carried on the great system of agricultural experiments that was begun there by Sir John Lawes fifty years ago; it is a pleasure to be able to record that Sir John has, by a special clause in his will, provided for the maintenance of this work during all future time. Of course the results attained in the climate of Rothamsted cannot be directly

applied to the climate of any part of the United States, and indeed the same may be said of the results attained in the special climate of any other locality, and this brings me to call attention to the fact that the study of climate has, in general, been prosecuted by European meteorologists to an extent and to a degree of refinement that is not yet attained in America, and perhaps scarcely appreciated by us. Thus, we speak of the climate of a state whereas we should speak of the climates within the state and of the climate of a special farm or even of a small field, because each individual plant prospers or languishes according as the temperature and moisture of its own locality is favorable or not; thus, an eminent climatologist, criticising the location of some instruments on a rise of ground and amid trees, possibly an hundred feet above the surrounding plain, objected that these instruments could not represent properly the climate of the surrounding country, but that they should have been placed in the open, flat fields near at hand. If this person be correct it is evident that the demands of agricultural climatology are very different from those of dynamic meteorology or the study and prediction of daily weather, and it will be an important result of our European journey if we shall have received a decided stimulus in the direction of minute climatology.

Through the kindness of Professor Mascart and his assistants, Messrs. Angot and Teisserenc de Bort, we were enabled to make a detailed examination of the meteorological station that crowns the summit of the Eifel tower, and the very interesting results obtained at this location make it desirable that similar use should be made of the tower that is proposed to be erected in connection with the Columbian Exposition at Chicago; it is only by means of stations on such towers and on mountain tops that we may hope to understand the motions going on within the atmosphere.

The international bibliography of meteorology, as begun by General Hazen and published in part by General Greely, seems to have attracted the greatest interest among European students, as it attempts to satisfy a want that has long been recognized. We were so fortunate as to enjoy a prolonged interview with Dr. Hellmann, at Berlin, and Mr. Symons, in London, the two Europeans who have probably done the most work in connection with the bibliography of meteorology. Evidently the general sentiment in Europe is to the effect that the work thus far done by the Signal Office is too important to be left unfinished, and that the interests of meteorology and of climatology alike demand that the Weather Bureau shall publish the complete work in proper style after obtaining from European co-laborers all possible corrections to the manuscript that has already been milleographed.

THE USE OF OUR DATA.

The enormous accumulation of meteorological records now in the Weather Bureau affords an opportunity for climatal and other special

studies and investigations which should be utilized to the greatest degree possible. We have now the observations for the twenty years during which the meteorological work was in the charge of the Signal Service and also those for many years before when in the charge of the Smithsonian Institution. I propose to utilize these data by special studies by the proper officers of the Bureau. Several studies of this sort are now under way and others are being organized. But I believe that we should pursue no exclusive policy in the treatment of our records. They should be thrown open to all students of meteorology, who are competent to use them, subject only to such restrictions as will preserve them from injury. I recommend that meteorologists be invited to make use of them in the Bureau. Space can be found for a limited number of such students and the necessary guidance and oversight given them.

RELATIONS TO THE AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

At the Conference of Agricultural Colleges and Agricultural Experiment Stations held in Washington in August, I proposed that these institutions should constitute themselves meteorological stations of the first order, devoted to climatological work, and to special studies of the relations between animals, plants, and climate. I also had the pleasure of offering to these institutions the services of the Bureau in every practicable way. The discussion which followed showed great interest in the work of the Bureau and resulted in the following resolution:

Resolved, That in the future extension and development of the Weather Bureau in the interests of agriculture, the Bureau should organize and assist in maintaining a study of climatology in its relations to farming, in co-operation with the agricultural colleges and stations, and that the sphere of this work should be enlarged to include the physics, conditions, and changes of agricultural soils.

The first part of this resolution is in entire accord with the present policy of the Bureau. The second part of the resolution introduces a subject entirely new to the work of the Bureau. The propriety of calling on us for such work, in the opinion of the framers of this resolution, probably lies in the fact that the physics of the soil is largely dependent on its weathering. It is a subject of the highest agricultural importance, but it would perhaps be advisable to confine immediate efforts at co-operation to the work at present in charge of the Weather Bureau, deferring consideration of the feasibility of the important work contemplated by the second clause of the resolution until a thorough system of the co-operation upon the present basis be fully perfected.

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